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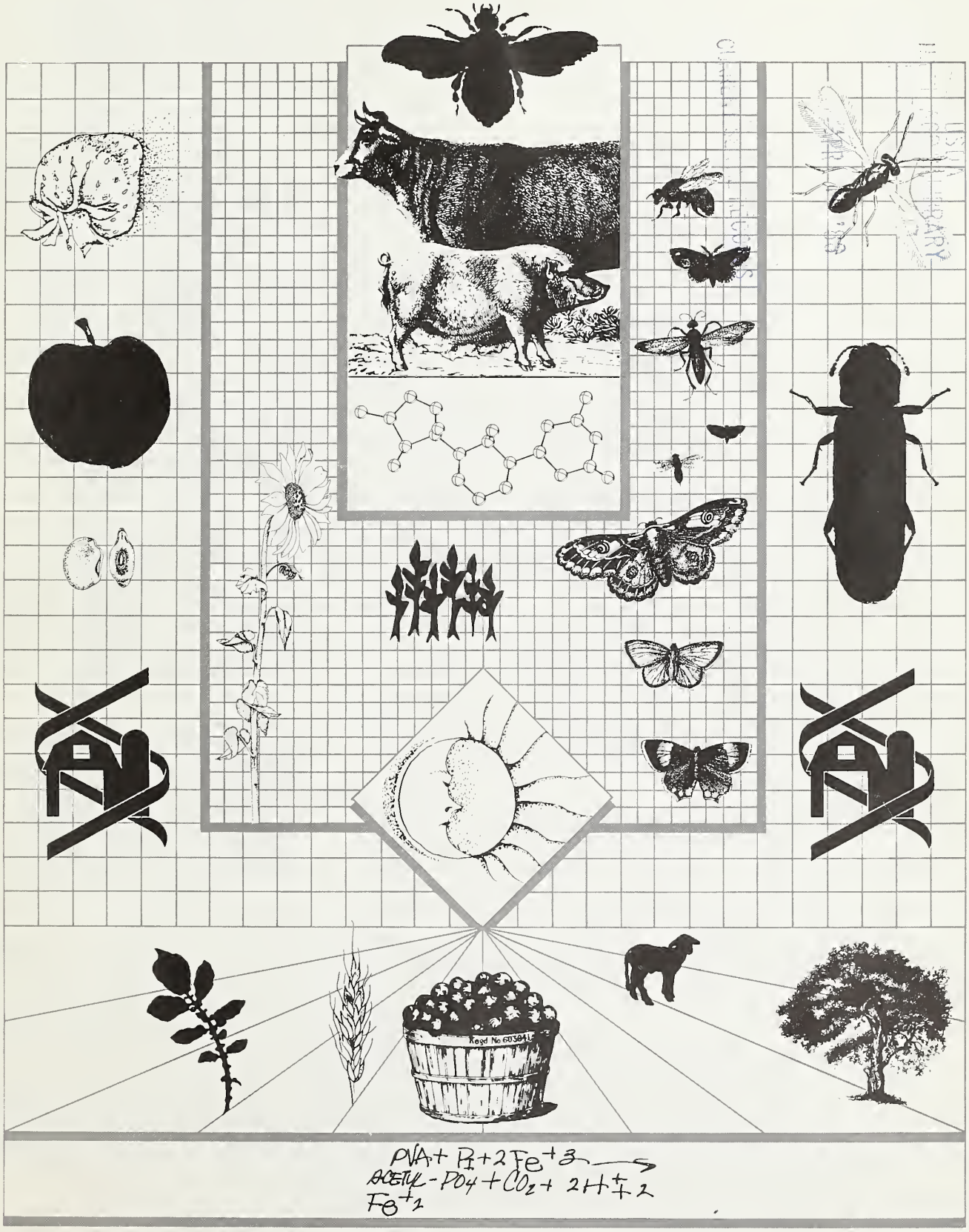
Agricultural Research



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Wanted: Developers for ARS Inventions

[The Agricultural Research Service makes many research discoveries that are patented by the U.S. Department of Agriculture. The following interview with M. Ann Whitehead, coordinator of the ARS National Patent Program, highlights recent progress in getting patents into use.—**Ed.**]

Ag. Res. Why does USDA patent its discoveries?

Whitehead. It's one way—the best way, as far as I'm concerned—of guarding against unfair, improper, or ineffective use of research which the public has paid for. By patenting research developments having a commercial potential, we can control their use through patent licensing agreements.

Ag. Res. ARS seems to be publicizing its patents more now than in previous years. Can you tell us why?

Whitehead. You are hearing more not only about ARS patents but all federal patents because of the Patent Law Amendments of 1980 and the Stevenson-Wydler Technology Act passed the same year. We're now starting to see results produced by these two pieces of legislation. The Patent Law Amendments give federal agencies the authority to award exclusive licenses on their patented technology, and the Stevenson-Wydler Act provides new ways to get inventions developed by federal agencies into the hands of private industry. Publicizing patents is vital to the whole concept of technology transfer, and exclusive licensing is making our patents far more attractive to business and industry.

Ag. Res. What do you mean by exclusive licensing and why is it so important to ARS?

Whitehead. Exclusive licensing means that the federal government can give one company or a limited number of companies the exclusive right to use research developed and patented by a federal agency. Without an exclusive right, there is little financial incentive for a company to invest heavily in one of our inventions.

Ag. Res. Why not?

Whitehead. Because once a company had refined and commercialized one of our inventions and then worked to establish viable markets for it, any other company could take the same ARS-based technology and compete in the same markets without having taken any of the risks. With exclusive licensing, companies that take the initiative and the risks won't have to worry about unfair competition from other companies that are simply waiting to see what happens.

Ag. Res. Doesn't this represent use of publicly funded research for the benefit of a select few?

Whitehead. Not at all. In fact, I would say the opposite is true. Without exclusive licensing, some of our research results might not get to the public—at least not in the form of a usable product or process—because of reluctance on the part of business to make the necessary investment. When an invention simply sits on the shelf, no one benefits. By protecting a business investment through exclusive licensing, we ultimately get the most for tax dollars that go into research. Also, a company must pay a royalty fee to the government for the exclusive use of one of our patents.

I should add here that we will continue to license selected patents on a nonexclusive basis—which means that they will be available to any company with the interest and capability of developing and marketing them. With each patent, we decide whether exclusive or nonexclusive licensing is the best way to get the technology used.

Ag. Res. How does the government determine whether to grant an exclusive license to industry?

Whitehead. You have to remember that research results do not always translate into an immediately marketable product. The question of whether or not one of our patented research developments should be licensed on an exclusive basis hinges largely on the amount of capital investment necessary to turn the invention into a commercially viable product.

Before we grant an exclusive license, we must advertise our intent to do so and allow a 60-day period for public comment. And we must establish that granting such a license will not tend to lessen overall competition.

Ag. Res. Can you give us a example of an ARS invention that has been exclusively licensed?

Whitehead. ARS recently developed a process for treating straw and other crop residues with hydrogen peroxide to make them wholly digestible by cattle. Applying the hydrogen peroxide process on a large scale, however, will require some additional technology and a lot of capital investment, and it was determined that exclusive licensing was necessary to make such a proposition worthwhile to private industry. Actually, we should call it a partially exclusive license in this case because three separate companies will have the right to commercially develop our process. [See story on page 7.]—Interview by **Steve Miller,** ARS, Beltsville, MD.

Agricultural Research

Cover art symbolizes the diversity of agricultural research.

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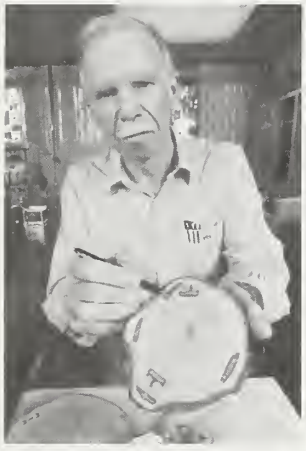

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DEPARTMENTS

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Jetstream Hitchhikers

Hitching rides on the jetstream takes some insects exactly where they want to go. The adult aster leafhopper, for example, travels this route from its winter hosts in the South to its summer food supply, including the barley fields of the North.

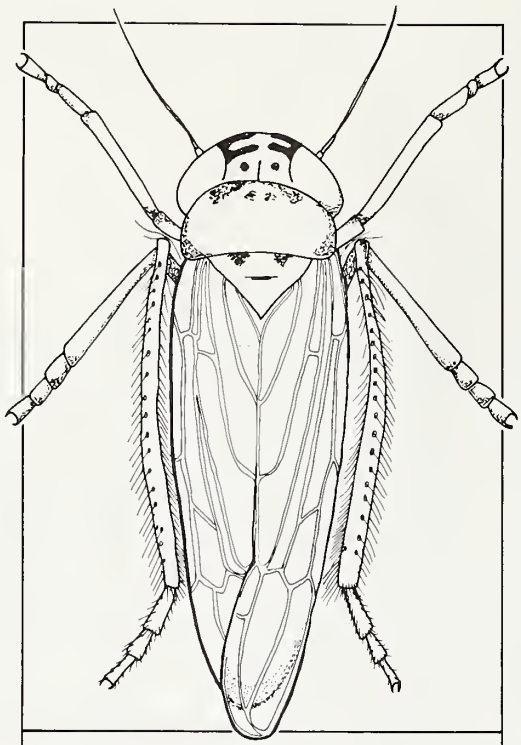
These migrants take off from Louisiana, Arkansas, and parts of Kansas and Missouri in mid-April when temperatures are 60°F or more. Blown north on the jet winds, they plague barley farmers with a virus that stunts the growth of emerging plants.

Damage varies with how early in the growing season the leafhopper lands and starts infesting new shoots. When arrival time coincides with new plant growth, usually in May, damage can be severe, and barley farmers can lose up to 25 percent of their grain crop.

Roland G. Timian, an Agricultural Research Service plant pathologist at Fargo, ND, found that about 15 percent of 800 adult leafhoppers *(Macrosteles fascifrons)* collected in May and June 1983 carried the oat blue dwarf virus. Because the virus has not been found in native plants and since it requires an incubation period of 2 to 3 weeks in the insect before the leafhopper can transmit the disease, Timian believes they acquire it from their winter oat or wheat hosts. He bases this conclusion on his discovery of the virus on winter oats in Arkansas.

Timian says planting barley earlier in the growing season will give the plants a better chance of escaping infection when they are most vulnerable to the severe stunting that results in yield losses.

In related research on migrating insects, William B. Showers, ARS research entomologist, Ankeny, IA, says that corn pests such as armyworms and cutworms also fly jet winds out of the south and can travel to northern states within a few days.—**Betty Solomon,** ARS, Peoria, IL.



Adult aster leafhopper. (PN-7198)

Roland G. Timian is with USDA-ARS Cereal Genetics and Pathology Research, Department of Plant Pathology, North Dakota State University, Fargo, ND 58105. ■

Mysteries of Plant Roots Tapped

Plant roots can tear apart granite boulders and upheave streets and sidewalks in their quest for water and nutrients. Like pry bars, roots penetrate minute cracks, then elongate and thicken to part some of the Earth's hardest materials.

Scientists have measured the pressures roots exert to penetrate soils—up to 150 pounds per square inch or five times the pressure in automobile tires.

"How roots penetrate soils to extract water and nutrients is not well understood," says Agricultural Research Service soil scientist Arnold Klute. He is now seeking additional information on roots to answer some of these questions.

First priority was inventing special research tools—including a miniature pressure gauge less than five millionths of an inch in diameter, to record pressures inside individual root cells, and sensitive rulers to measure root growth, often less than one thirty-second of an inch per hour.

Using this equipment, Klute and Colorado State University graduate student Douglas E. Emery were able to detect in growing root tips minute pressure changes caused by the plant's environment.

They discovered that plant roots will sometimes stop growing during the day. Other researchers have reported that roots stop growing in response to stresses such as lack of water, but Klute and Emery are the first to detect a daily cycle.

"The beauty of the micropressure probe is that we don't have to cut up the plants to use it. Previous studies necessitated actual root removal and destruction. We can check the root several times as it grows right in the soil," says Emery.

Greenhouse studies with pinto beans indicate that root growth is faster in daylight than in darkness but pauses when temperatures reach about 110°F with relative humidity about 30 percent.

The studies have been moved to a smaller, more accurately manipulated environment—a growth chamber—which will allow tests of several other variables, including carbon dioxide and relative humidity, that may affect root growth.

Klute says their research is basic but will yield information necessary to analyze a plant's ability to penetrate compacted or dry soils. "Eventually we want to

predict how readily a root system will penetrate soil to find new water. This information would help plant breeders in their search for better plants."

Another benefit from the research will be the knowledge needed to improve computer programs that turn irrigation pumps on and off. These programs are often elaborate but contain only generalized information on root growth, says Klute.—**Dennis Senft,** Albany, CA.

Arnold Klute is in USDA-ARS Soil-Plant-Water Research, Agronomy Department, Plant Science Building, Colorado State University, Fort Collins, CO 80523. ■

Bollworms Find Okra-Leaf Cotton Less Tasty

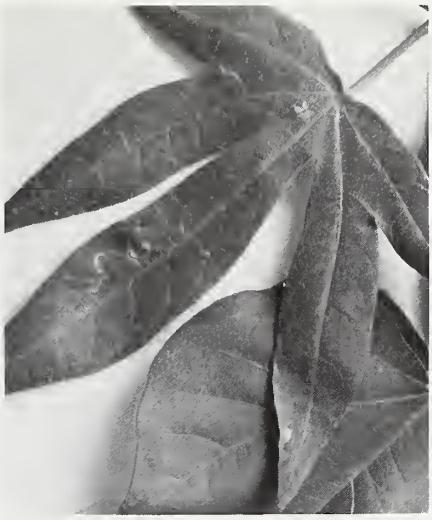
Cotton plants whose leaves have deeper than normal indentations between the lobes may have added protection against the destructive pink bollworm.

"Some cotton plants that have these okra-type leaves showed 30 percent less damage than commercially available, normal-leaf varieties," says Agricultural Research Service plant geneticist F. Douglas Wilson.

Okra-leaf cottons may contain specific chemicals or have tougher boll walls that discourage insect feeding, he says. In field tests near Phoenix, AZ, Wilson compared these cotton plants with normal-leaf varieties over two growing seasons for yield and seed damage. All were grown without insecticides so resistance to pests could be checked without interference from these chemicals.

One okra-leaf variety already commercially available yielded 7 percent more marketable cotton than a popular normal-leaf variety.

Wilson thinks it is possible to incorporate this insect resistance and yield advantage into other commercial varieties.



Okra-shaped cotton leaf has much deeper indentations between lobes than does the normal cotton leaf beneath it. (PN-7197)

Experimental okra-leaf versions of commercial varieties have been developed. Four out of eight in Wilson's study had significantly less seed damage caused by the pink bollworm than did the normal-leaf varieties.

However, none of the experimental versions available to Wilson yielded as much cotton as the normal-leaf parent varieties. More recently developed versions may be better, he says.—**Dennis Senft,** ARS, Albany, CA.

F. Douglas Wilson is at the USDA-ARS Western Cotton Research Laboratory, 4135 East Broadway Road, Phoenix, AZ 85040. ■

Exploring East for Landscape Plants

Explorers from the Agricultural Research Service's U.S. National Arboretum travel the globe in search of new ornamental crops.

Averaging one or two trips a year, they bring back new plants, seeds, and cuttings. Recently, they visited Japan and the Republic of Korea.

The Korea trip marks the second year in a 5-year program to explore its plantlife.

Barry Yinger, curator of Asian collections, and botanist Theodore Dudley collected seeds and cuttings from hollies, broadleaf evergreens, *Viburnum* species, and other trees and shrubs. These materials will be used for research and crossbreeding and, in some cases, as newly introduced landscape plants.

Korea was chosen because its climate is so similar to that of the eastern United States.

Also, scientists are anxious to collect samples of Korean species before urban development to accommodate a fast-growing population makes many of them extinct. Dudley says the islands off Korea's coast offer plants that do not exist anywhere else in the world.

Sylvester G. March, a horticulturist, spent a little more than a month in Japan collecting mainly dwarf flowering shrubs, flowering trees, and ground-cover plants. The specimens he collected were chosen from among those sold as garden plants in Japan but not in the United States.

He looked for specimens with the characteristics that help make a plant commercially successful—insect and disease resistance, hardiness, and beauty.

March says Japan was chosen for this collection "because it is an ancient culture whose people have been selecting plants for garden use for hundreds of years."

The Friends of the National Arboretum, Inc., a private nonprofit group, sponsored the trips to Japan and Korea, as they do most Arboretum exploration trips. Funds for sponsored trips come from private groups and individuals.—**Jessica Morrison,** formerly with ARS, Beltsville, MD.

Barry Yinger, Theodore Dudley, and Sylvester G. March are at the USDA-ARS National Arboretum, 3501 New York Ave., NE, Washington, DC 20002. ■

Designer Genes for Better Crops

By the 1990's, scientists may be routinely putting blocks of genes into plants so crops can better handle drought or salty soils.

Robert J. Griesbach, a plant geneticist with the Agricultural Research Service in Beltsville, MD, has developed a series of techniques that allow him to transfer blocks of genes from one plant cell to another and have the genes function. He injects the chromosome or part of a chromosome carrying the desired genes into a cell with a microscopic glass needle.

According to Griesbach, "plant characteristics, such as the ability to withstand high levels of salt or periods of drought, are almost always controlled by multiple genes—a block of 50 to 100 genes on a chromosome."

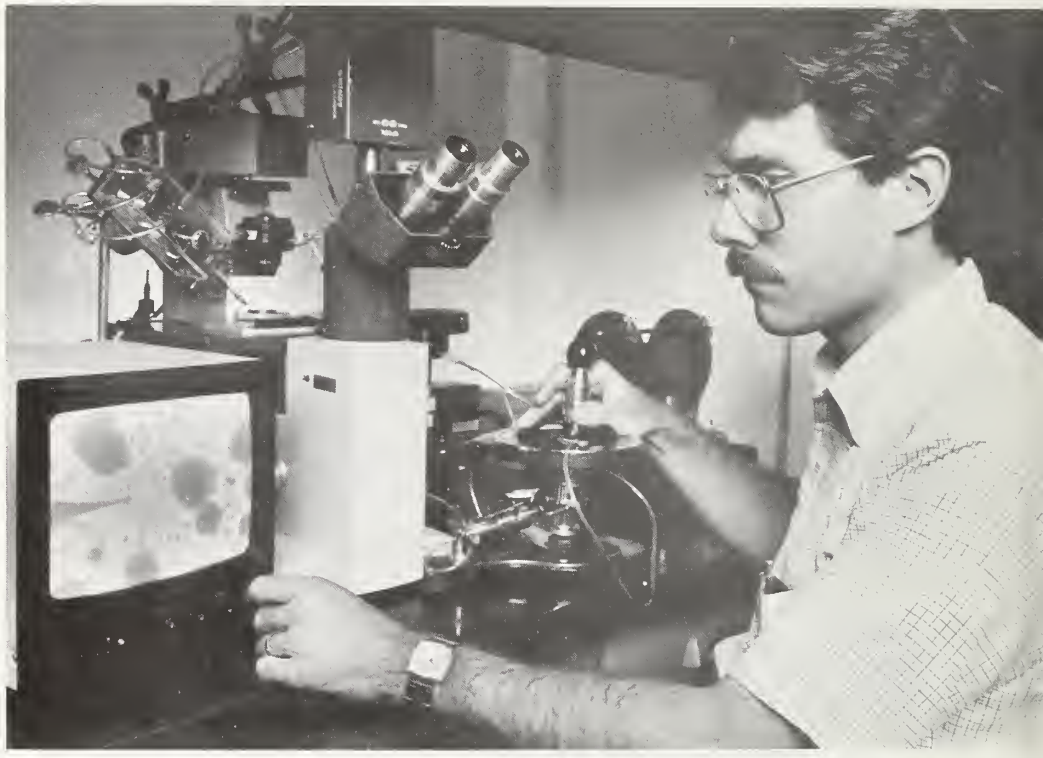
This is far too many genes to transfer using viruses or bacteria, he says. It would be like attaching 50 to 100 freight cars to a locomotive designed to pull 3.

Genetic engineering for plants is still in its infancy, Griesbach says. "But the possibilities are enormous, and developments will come quickly once they get underway." He says three other laboratories are now attempting to microinject genes into plant cells.

Scientists have been successfully injecting genes or chromosomes into animal cells since 1980, but plant cells have two major obstacles. First, a rigid cell wall has to be carefully peeled away with enzymes before chromosomes can be removed or injected. The peeled plant cell is called a protoplast.

Then, it is virtually impossible to inject chromosomes without puncturing the vacuole, which occupies about four-fifths of a plant cell.

Griesbach's techniques solve the major problems that have confronted scientists attempting to microinject plant cells. For example, he first removes the large central vacuole, which, among other things, traps and recycles the cells' toxic metabolites.



With help from a microscope attached to closed-circuit television, plant geneticist Robert Griesbach prepares to inject a chromosome into a petunia cell magnified 15,000 times. (0485X370-31)

While at Michigan State University, Griesbach and Kenneth C. Sink developed a technique for removing the vacuole without damaging the protoplast.

The technique relies on the principle that oil is lighter than water. The vacuole contains more oily chemicals while the remainder of the cell contains more water. By spinning the protoplasts in a centrifuge at 250,000 times the force of gravity, the vacuole rises to the top of the protoplast and eventually pinches off.

The protoplast will begin to regenerate a new vacuole in 24 hours, Griesbach explained, but that gives him enough time to inject chromosomes successfully.

At present, he said, "the lack of sophisticated tissue culture techniques for most varieties of agricultural crops is the major barrier to

Griesbach removes pollen from a drought-resistant petunia to cross with a new petunia (right), created through microinjection of chromosomes. Resulting seeds from the cross will be analyzed to determine if the inserted chromosomes contained genes for drought-tolerance. (1185X1234-27)

wide application of genetic engineering technology to plants."

Griesbach is using his techniques to improve the petunia because it is one of the few plants that can be regenerated from a protoplast to a whole plant in tissue culture. But the techniques can be used to genetically engineer any plant, he said. He also noted that the petunia is the most popular ornamental bedding plant worldwide.

He is working towards inserting chromosomes that contain genes for drought tolerance but first has to determine which chromosomes carry these genes. Although gene maps are extensive for a number of animals, he said, not many plant genes have been mapped.

Griesbach works over a microscope attached to closed-circuit television. A video monitor projects a picture of the cell he is injecting at 15,000 times life size. He uses a tiny glass needle to enter the cell, then gives quick blasts of pressure from two nitrogen tanks to propel the chromosome into the cell's soupy contents.

For such a delicate operation, he says, "I don't rely on a steady hand; I use a micromanipulator to guide the needle into the cell."

About 25 percent of the wall-less petunia cells he has injected with a chromosome can be coaxed into growing roots and shoots in a culture medium. Griesbach says this is a good return for cells that have undergone such manhandling.

Scientists have also inserted chromosomes into plant cells by enclosing them in lipid envelopes and fusing the envelopes with protoplasts. Once inside, however, the lipid envelope has to be removed, Griesbach said, and that can be very tricky. The enzymes used to degrade the lipids can also destroy the chromosomes.—**Judy McBride,** Beltsville, MD.

Robert J. Griesbach is at the USDA-ARS Florist and Nursery Crops Laboratory, Bldg. 004, Room 108, BARC-West, Beltsville, MD. ■

Crop Wastes Converted to Livestock Feed

Lamb eats straw made digestible with hydrogen-peroxide, sweetened with molasses, and supplemented with corn and other ingredients. Biochemist J. Michael Gould and University of Illinois animal scientist George C. Fahey, Jr., look on. (0783X865-14)

Two companies have been licensed by the federal government to use a new chemical process developed by an Agricultural Research Service scientist for converting indigestible and often wasted crop residues into high-quality feed for cattle.

The process, in which crop residues are treated with a solution of hydrogen peroxide so that cattle can digest them, is being patented by USDA and licensed through the Department of Commerce's National Technical Information Service. It was invented by J. Michael Gould, a biochemist at the Northern Regional Research Center, Peoria, IL.

"The leaves and stems of crops like corn, wheat, oats, rice, and barley pack a lot of carbohydrate energy in the form of fibrous cellulose," says Gould. "Normally, the cellulose can't be efficiently digested by cattle. A plant substance called lignin glues cellulose fibers together and shields them from bacteria in the animal's digestive tract."

"But treating the residues with hydrogen peroxide dissolves the lignin so that the digestive bacteria can reach the fibers."

Gould says that hydrogen peroxide, a common antiseptic and bleach, can also be used on crop residues to facilitate the production of industrial-grade ethyl alcohol. (See *Agricultural Research,* July/Aug 1983, p. 12.)

M. Ann Whitehead, patent coordinator for ARS, says that rights to the commercial use of Gould's invention have been granted to Birks Agricultural Products, St. Paul, MN; and Interox America, Houston, TX.

She says that the companies will pay royalty to the government. A third company, Southwest Bio-Energy, Clovis, NM, will probably be licensed to use the process in the near future.—**Steve Miller,** ARS, Beltsville, MD.

J. Michael Gould is at the USDA-ARS Northern Regional Research Center, 1815 N. University, Peoria, IL 61604. ■

Snow is Water in the Bank

Tall wheatgrass barriers on a Montana farm trap snow to increase stored soil water. (MONT-10211)

Blowing, drifting snow may not seem like an asset in most places, but it could make annual cropping more profitable on 28 million acres of the northern Great Plains.

Current practice for many farmers in this area is to raise a grain crop only every other year so that soil moisture may accumulate during the years the land is fallow.

Five-foot-high natural snow fences of grass could make this practice unnecessary. Additional water from the melting snow, plus more efficient fertilizer use with the extra moisture, gave Agricultural Research Service scientists a nearly 50-percent increase in grain production. Wheat yields averaged 23.2 bushels per acre per year compared with 15.7 bushels under the alternate year, spring wheat and fallow system, says Alfred L. Black at Mandan, ND.

Under annual cropping with grass snow barriers, about 80 percent of the precipitation and soil water available was used by crops. With the spring wheat/fallow system, an average of only 45 percent of the total water available over a 2-year period was used.

"The fallow system is quite obviously a very inefficient water-storage method," he says. "The conventional spring wheat/fallow system consistently produced less grain per acre and less net income and used less of the available water than any other cropping sequence we studied."

Black, now head of the Northern Great Plains Research Laboratory, worked with ARS soil scientists J.K. Aase and the late Francis H. Siddoway on the project, which they began in 1968 at Sidney, MT.

Tall wheatgrass planted in two rows 36 inches apart, running north and south and spaced to leave a 48-foot cropping area between them, provided the snow barriers. The researchers compared annual cropping with two other systems—2 cropping years out of 3 (winter wheat, spring wheat, and fallow) and 1 cropping year out of 2 (spring wheat and fallow). They also compared nitrogen fertilization at 30 pounds per acre with no nitrogen.

With grass barriers and annual cropping, the soil stored 3.1 inches of water—48 percent of the precipitation—during the 9 months between harvest of one crop and the planting of the next.

With alternate year cropping and no snow barriers, the soil retained only 3.5 inches of water or less than 17 percent of the total precipitation between crops.

Black says, "During the fallow period, most of the precipitation is lost to evaporation, with smaller amounts lost as runoff and deep percolation below the root zone."

Nitrogen is necessary to efficiently use the additional water saved through snow management, Black says, even though water is the most limiting factor in annual cropping systems. This dictates that specific soil water conservation practices, such as fall weed control, snow trapping, and maintaining upright stubble, be used. Nitrogen becomes the second most limiting factor. In the Montana tests, nitrogen applications of 60 pounds per acre did not show significant yield increases over applications of 30 pounds per acre.

Although the fallow system provides a degree of production stability, it wastes water and provides little control of wind and water erosion, Black adds.—**Ray Pierce,** ARS, Peoria, IL.

Alfred L. Black is at the Northern Great Plains Research Laboratory, PO Box 459, Mandan, ND 58554. ■

Effect of Snow Barriers and Added Nitrogen Fertilizer

(Average grain production in pounds per acre over 18-year test period.)

	No nitrogen	*30# of nitrogen*
Annual cropping w/snow barriers	900	1,390
Spring wheat-winter wheat-fallow	860	1,200
Winter wheat-fallow	890	1,060
Spring wheat-fallow	720	940

Cataract Prevention May Be In Sight

New studies could make cataract surgery the treatment of last resort by the turn of the century, according to a biochemist at the U.S. Department of Agriculture's Human Nutrition Research Center on Aging at Tufts University in Boston.

Allen Taylor, director of the Center's laboratory for Nutrition and Cataract Research, says that people may be able to delay the progressive clouding of the eye's lens through diet or medication.

With funding from USDA's Agricultural Research Service, Taylor and colleagues are finding how and why cataracts form and what substances—such as vitamins and minerals—guard the lens from the damaging action of sunlight and oxygen.

Nearly 400,000 new cases of age-related cataracts occur in the United States each year.
—National Society To Prevent Blindness

"Our objective is to help the lens protect itself," says Taylor. "Preventive measures would dramatically reduce the medical costs for cataract surgery—currently the only effective treatment for cataracts—and enhance the quality of life for the elderly."

According to the Congressional Subcommittee on Health and Long-Term Care, Americans will spend a minimum of $3.5 billion this year to have clouded lenses surgically removed and replaced by artificial lenses.

In 1977, about 3.6 million Americans had some visual impairment due to age-related cataracts, according to a National Society To Prevent Blindness survey, and nearly 400,000 new cases occur each year.

Taylor expects that his research group could begin making dietary recommendations to extend the life of the lens within 5 years. Protective eyedrops containing vitamins or other antioxidants will take longer to reach the public because they have to be approved by the U.S. Food and Drug Administration, he says.

Lenses taken from animals with sufficient vitamin C are better able to withstand normal oxidation from light than those from deficient animals.

In tests using lens cells kept alive in a nutrient solution and homogenized whole lenses, experimental pathologist Joanne Blondin of the cataract research group recently showed that dietary vitamin C does concentrate in the eye lenses of guinea pigs.

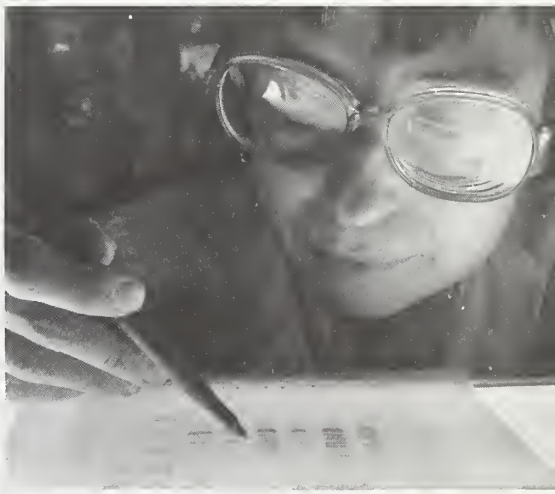
In more chemically oriented experiments, Blondin found that vitamin C can prevent sunlight and oxygen from oxidizing the lens' unique crystallins—proteins highly specialized to transmit light.

Other antioxidants, such as vitamin E and certain aspirin derivatives, will also protect the crystallin proteins, Taylor says. Studies are now underway to see if oral doses of vitamin E also move into the lens and have protective effects.

Lens cells are composed almost entirely of these proteins dissolved in water. The crystallins are arranged so they transmit light the way fiber optics do, Taylor explains.

When damaged, the crystallins clump together the way clouds form from droplets of water. Normally, the lens contains enzymes that break down the clumps and dispose of them. But the enzymes are proteins, too, Taylor says, and thus subject to damage the same as the crystallins. As people age, the enzymes are less and less able to clear away the damaged crystallins, which accumulate to form cataracts.

Cynthia Peltier, a graduate student with the research group, found that the minerals manganese and magnesium greatly enhanced the ability of certain enzymes to digest proteins and thus erase the clouds. However, this research is at an earlier stage than that for vitamins. Dietary recommendations for mineral levels will probably come later than for antioxidants, Taylor says.



Top: "Slit-lamp" test is performed on a rabbit's eye by biochemist Allen Taylor to determine whether cataracts have occurred. (0186X041-12)

Above: Experimental pathologist Joanne Blondin examines rabbit eye lens' protein patterns to see whether protein damage has been delayed by vitamin C supplements. (0186X040-22)

As a future alternative to cataract surgery, Taylor proposes injecting clouded lenses with enzymes. "Through our research, we know which enzymes dispose of damaged crystallins and what substances turn the enzymes on or turn them off."—**Judy McBride,** ARS, Beltsville, MD.

Allen Taylor is at the USDA-ARS Human Nutrition Research Center on Aging, Tufts University, 711 Washington St., Boston, MA 02111. ■

Trees Never Heal, They Just Seal

Cross-section cut from a tree shows chisel wounds. Geneticist Frank Santamour points to rectangular areas that demonstrate the tree's ability to contain or wall-off damage. (0985X969-31A)

A whole new way of thinking about trees—sometimes called "a new tree biology"—has emerged from recent research done in U.S. Department of Agriculture laboratories.

"The new thinking could make trees on public streets healthier and safer," says Frank S. Santamour, Jr., a geneticist at the Agricultural Research Service's National Arboretum in Washington, DC.

Santamour and Alex L. Shigo, formerly a plant pathologist with the U.S. Forest Service in Durham, NH, are key figures in the new tree biology. Their ideas are moving tree care away from traditional methods, many of which have been based on animal care practices.

"The difference is in how trees and animals respond to injury," Santamour says.

An animal heals by replacing damaged cells with new, healthy ones. A back yard tree "attacked" by a carelessly operated lawnmower, on the other hand, responds to injury by compartmentalizing, separating itself from the damaged area in two steps.

Trees are genetically programmed to varying degrees for the first step—surrounding wounds with a chemical barrier to limit the spread of decay-producing organisms. If done fast enough, decay cannot spread to healthy tissue.

The second compartmentalization step takes place in the wood grown after the injury. The cambium, or growth layer, forms a decay-resistant wall to protect new growth. The success of this step depends on the speed of the first one.

"We do know that there are individual trees within a species that can compartmentalize much more effectively than other trees within the same species," Shigo says.

The fact that trees with the best genetic capacity to compartmentalize don't decay to the point where they might break is a benefit for trees and for people or property near them, Shigo says. "These trees are the healthiest, toughest, and safest trees within a species."

Using a technique developed by Santamour, tree breeders can test a tree for walling-off ability before spending the time and money to propagate it.

A chisel is driven through the bark and into the wood of a tree in its second growing season. After one more season, the top part of the tree is cut off—just enough for a cross section of the wounded area but not so much that the tree can't grow new sprouts.

The age-old practices of cutting and grafting—which severely wound trees—have served as a sort of natural selection for the strongest "wallers."

If a brownish stain spreads in toward the center of the tree, decay has gone beyond the wound into new wood. This tree has clearly not walled off its wound. A grower could therefore eliminate it when checking for other desired characteristics, such as leaf color.

However, if there is a dark line completely surrounding the wound and accompanying decay, the tree has successfully contained the damage. This tree would be a top candidate for propagation.

With Santamour's test helping to select the trees of the future, they could be safer, healthier, and longer lasting.

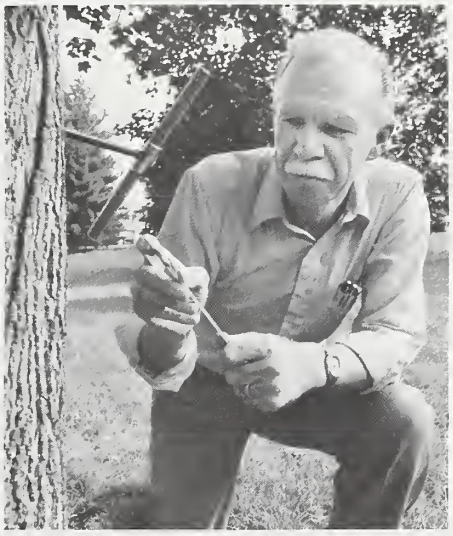
It appears that breeders and growers have inadvertently put some of the best specimens into the hands of consumers and onto city streets already, according to Santamour.

He tested 20 varieties of popular landscape trees—the Bradford pear, for example—and found that all of them walled off wounds and protected themselves from decay.

He says that the age-old practices of cutting and grafting—which severely wound trees—have served as a sort of natural selection for the strongest "wallers."

However, Santamour says, trees grown from cuttings or grafts make up only about 2 percent of the landscape trees on public streets.

Tree cross-section on right shows good walling-off ability. But wounds shown in cross-section on left have not been walled-off, leaving the tree susceptible to micro-organisms that have spread decay to the heart of the tree. (0985X970-4)



At the U.S. National Arboretum, Santamour inspects a wood core extracted to look for discoloration caused by wounding. (0985X969-22)

The other 98 percent consists of trees planted from seeds. How well these trees "wall" depends on their individual genes, and Santamour's test is really the only way to gauge that ability.

Shigo says trees have been cared for improperly for many years. The misunderstanding has resulted because "concepts developed to explain animal biology are applied, almost unconsciously, to trees." In many ways, trees are treated like animals or human beings.

For example, people put dressings on their wounded trees. Shigo says that dressings have no value in helping a tree "get better" since the chemical barrier it puts around the wound is all that is really needed.

In addition, Shigo says, tree surgeons have traditionally dug out cavities of decay right into healthy wood—much like a dentist might drill a decayed tooth. But doing so only exposes healthy tissue to infection and decay.

The new tree biology is offering tree surgeons new ideas about tree pruning, too. Traditionally, surgeons have pruned trees by using a "flush cut." This cut, in which the surgeon puts the pruning saw right up against the trunk and then cuts straight down, damages the collar.

The collar, the swollen base of the branch, houses the secret to preventing decay after pruning—it supplies chemicals for walling off infection. Cuts into the collar literally open the tree up to invasion by insidious micro-organisms.

In fact, ARS researchers in Kearneysville, WV, have found that several very serious diseases of fruit trees stem directly from the flush cut, including *Cryptospora* canker in peach trees.

Improper cuts also turn trees into tempting treats for insects, Shigo says. "We can remedy a whole host of problems we have now by proper pruning."

To prune a branch, he says, a surgeon should cut it as close to the tree's collar as possible, without ever touching the collar itself.—**Jessica Morrison,** formerly with ARS, Beltsville, MD.

Frank S. Santamour, Jr., is at the USDA-ARS National Arboretum, 3501 New York Ave., NE, Washington, DC 20002. ■

Female Fruit Flies Desire Loud Males

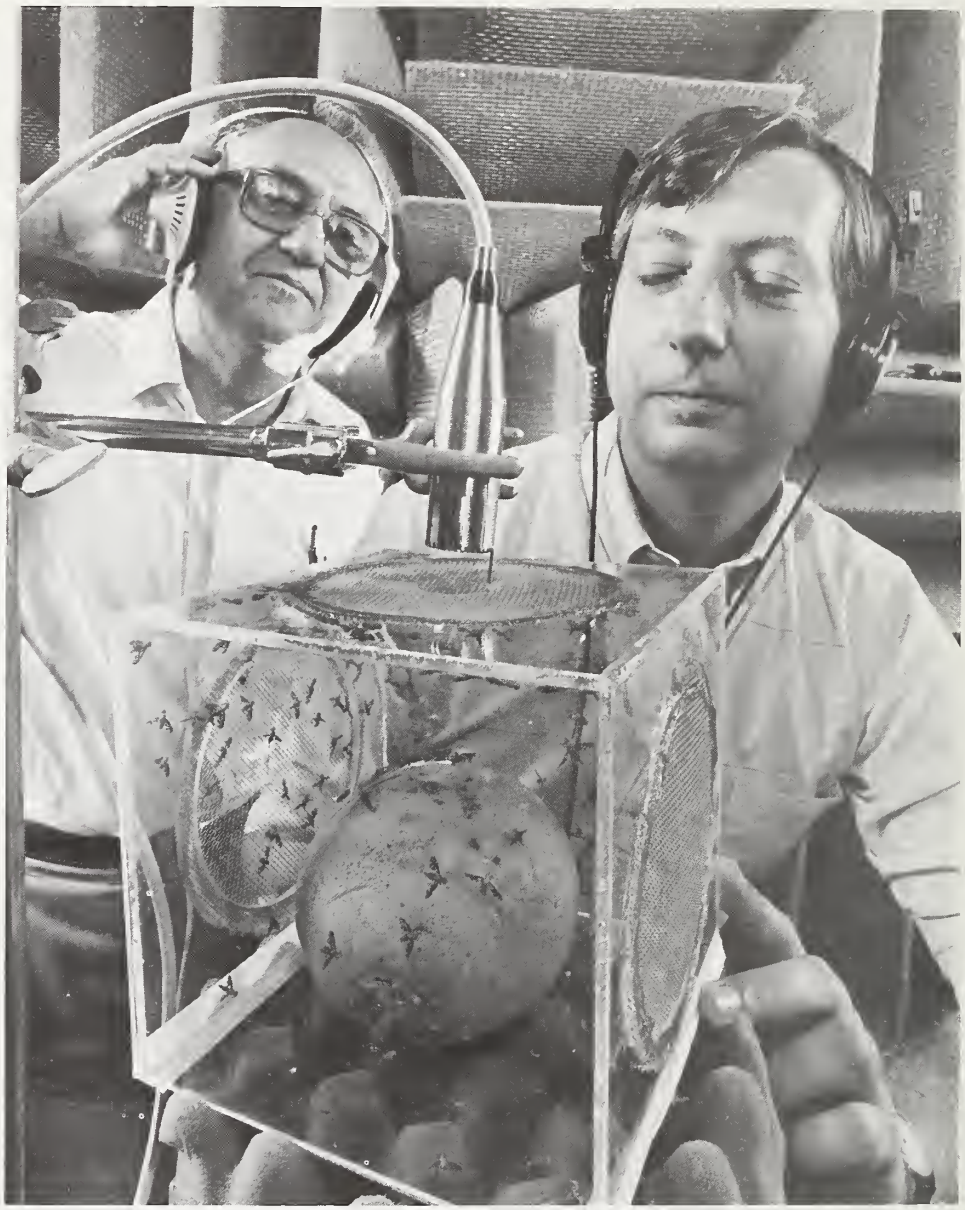
Raising the volume of male fruit fly serenades could help lower the fruit fly population, proving that loud music isn't just for teenagers.

Females find the louder, faster buzzing of larger males more seductive and the males easier to locate.

Armed with data based on ultrasensitive sound recordings, entomologist John M. Sivinski, in Gainesville, FL, says that male flies raised for sterile-release programs should be larger and have more robust singing styles so that more females will zero in on them.

"When a sexually attractive male fruit fly also happens to be sterile, that's it—there'll be no offspring, and the females probably won't mate again."

—John M. Sivinski, entomologist.



In their soundproof studio in Gainesville, FL, entomologist John Sivinski (right) and agricultural engineer J.C. Webb record mating songs of captive Caribbean fruit flies. (1285X1334-15)

Sivinski has been investigating ways to more effectively use sterilized insects against the Caribbean fruit fly, which is similar in behavior to the Mediterranean fruit fly.

"The release of massive numbers of sterilized male insects into the wild can reduce an insect population by causing females to waste their reproductive capacity," explains Sivinski, "provided the females are attracted to the males."

"When a sexually attractive male fruit fly also happens to be sterile, that's it—there'll be no offspring, and the females probably won't mate again."

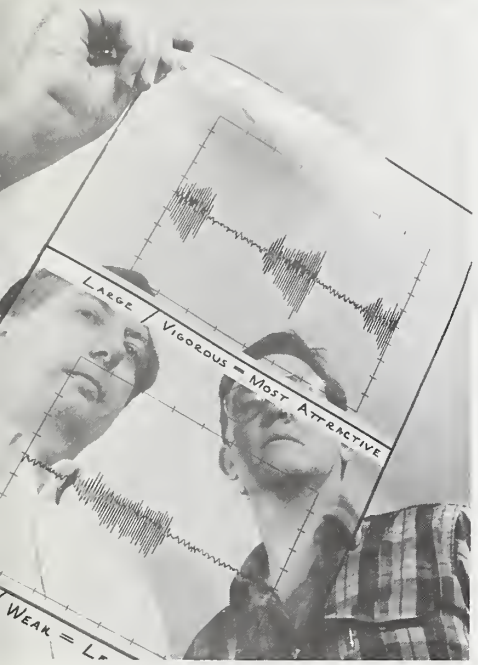
Sivinski's research depends on sound recordings made by J.C. Webb, an agricultural engineer who has built equipment that can detect minute sounds made by insects, including those of fruit fly larvae chewing inside a grapefruit. (See *Agricultural Research,* April 1985, pp. 13-15)

"The relationship of sound and behavior has become increasingly important to insect control," Webb says.

By recording insects inside a chamber equipped with microphones that could easily pick up the noise of a sharp knife slicing through soft butter, Webb has built an extensive library of courtship songs from the Caribbean fruit fly and numerous other insects.

Male fruit flies produce intermittent buzzing sounds by beating their wings about 150 times per second. In a large male fruit fly, the buzzing comes at half-second intervals. In smaller males, the intervals are longer.

When male and female fruit flies finally get together and sexually couple, the intervals between buzzing vanish and the entire serenade acquires a higher frequency and greater volume.



Top: Attractive to his mate because of his intense song, this sterile fruit fly will impart no progeny. (1285X1336-14)

Above: Sivinski and electronic engineer Carl Litzkow study wave forms or signatures of fruit fly songs. The signatures, distinctive by species, have been transcribed onto acetate from studio recordings through frequency analysis and digital plotting. (1285X1335-15)

"If the volume isn't sufficient," says Sivinski, "the female will literally throw off the male. And small males can't sing loud enough." —**Steve Miller,** Beltsville, MD.

John M. Sivinski is at the USDA-ARS Insect Attractants, Behavior, and Basic Biology Research Laboratory, Gainesville, FL 32604. ■

Microphones Monitor Plants' Water Needs

Like parents aroused from sleep by a crying child thirsty for water, farmers may someday listen for tiny popping sounds plants make when they need water.

Miniature microphones and supersensitive electronic measuring equipment now make it possible for scientists to record such sounds says Edwin L. Fiscus, an Agricultural Research Service plant physiologist at Fort Collins, CO.

During the past two summers, Fiscus monitored the high-frequency popping sounds given off by the xylem, or water tubes, in corn plants.

"The number of pops that the equipment detected appears to indicate how much water stress the corn is undergoing," he says. "This may give us an indication of when to irrigate rather than waiting for some other sign, such as wilting."

Fiscus explains that the popping sounds are made as the xylem carries water and nutrients from roots to leaves. When there is enough water in the soil, water moves upward through these tubes under tension. When soil is dried out or when plants need more water than is available, the tension in the tubes becomes too great and the water tube breaks, making a popping noise.

Air pockets form in the water tubes when they fracture. Some plants refill their tubes at night if there is enough water in the soil. These plants are then ready the next morning to continue growing. Plants that can't refill their water tubes wilt.

Some farmers, like many gardeners, apply water to their plants after they notice wilting. While the plants more often than not seem to recover from this stress, their growth and eventual yield may have been reduced. Other growers prevent this possibility, but waste water, by irrigating too often, Fiscus says.

The plant-acoustics research is part of an overall project to find an easy, reliable way to monitor water stress in crop plants. It is being carried out in cooperation with Melvin T. Tyree, a biophysicist at the University of Vermont in Burlington, who developed the equipment and supervised its installation and use during these experiments.

Plants are very noisy when they grow. Various parts, such as the corn leaves and the stalk, make noise when they slide against each other. The rustling of leaves in a breeze and the bending of the stalk are other sources of noise. Tyree says, "To hear the water tubes popping, we had to filter out everything else."

The miniature microphone operates at frequencies around 100 kilohertz or about five times the highest frequency detectable by humans. At this level, only the sounds created by the plant's breaking water tubes are recorded.

Stanley D. Wullschleger, a plant physiologist who worked with Fiscus, says their data will provide basic information on plant growth. Other scientists might use this information to find plant varieties that are better equipped to move water and nutrients from roots to leaves than other plants in the same species.

"This might lead to a new way to select superior plants for feed and food production as well as increase the efficiency of water use by irrigators," says Fiscus. —**Dennis Senft,** ARS, Albany, CA.

Edwin L. Fiscus is in USDA-ARS Soil-Plant-Water Research at the Crops Research Laboratory, Colorado State University, Fort Collins, CO 80523. ■

New Flower Seed Thresher Cuts Hand Labor

Beautiful flowers often have seeds armed with barbs, stickers, or hairs that protect the seeds but interfere with planting.

Flower seeds, such as marigold, gazania, arctotis, and anemone, which are grown primarily for the bedding plant and cut-flower industries, often have seed appendages that are very difficult to remove with conventional equipment.

Seed processors often have to remove these by hand. Otherwise, they tangle with other seeds and bits of debris and reduce the ability of precision mechanical planters to place single seeds in the soil at proper intervals and depths.

When seeds cannot be conditioned for machine planting, they must be planted and thinned by hand, thus raising production costs.

Enter on the scene a new, whirling-filament seed thresher that may solve this problem. Its nylon line knocks undesirable structures off a seed much like a string trimmer cuts weeds around a lawn.

"Seed threshers that use a rubbing action can't remove the more fuzzy, hairy appendages and tend to damage seeds," says agricultural engineer Arnold G. Berlage of USDA's Agricultural Research Service. "On the other hand, machines that use compressed air require a lot of energy and produce considerable dust."

The filament seed thresher was invented by Berlage and Douglas M. Bilsland, a research assistant in the Department of Agricultural Engineering at Oregon State University. It includes a chamber for seeds to be threshed, a system to draw air through the chamber to suspend seeds with appendages, and a rotating shaft of spools mounted in the chamber.

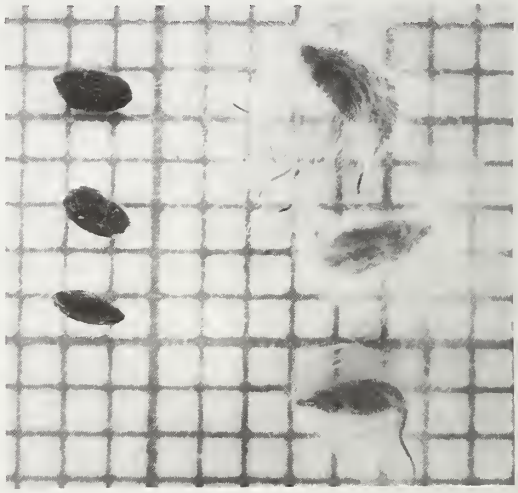
During operation, filament unrolling from the spools contacts the suspended seeds and removes the appendages. The appendage-free seeds drop to the bottom and are discharged from the container.

The filament seed thresher also provides a means of threshing seeds used for food, spice, oil, or other nonplanting uses. For example, the machine can remove the hull from certain oilseeds to obtain a husk-free seed, thereby increasing the oil percentage of the seed product.

"At present, we are experimenting with conditioning small volumes of high-dollar-value seeds," says Berlage. "But we think the machine can be scaled up to handle greater volumes."

A patent has been applied for, and individuals interested in manufacturing the machine or using the process can now apply for a license.—**Howard Sherman,** ARS, Albany, CA.

Technical information is available from Arnold G. Berlage at the National Forage Seed Production Research Center, Rm. 2074 Cordley Hall, Department of Botany, Oregon State University, Corvallis, OR 97331. ■



Anemone seeds before cleaning (right) are covered by down-like hairs. Anemone seeds on left were cleaned in the whirling-filament seed thresher. (0186X112-17A)

Left: Agricultural engineer Arnold Berlage (left) and Oregon State University research assistant Douglas Bilsland with a laboratory scale model of their new flower-seed thresher. (0186X112-10A)

Night Light Curbs Hydrilla Reproduction

By shining light on hydrilla at night, Agricultural Research Service researchers may have found the safest and cheapest method yet tried for controlling this extremely fast-growing aquatic weed.

In an experiment site on the Potomac River in Virginia, Lars W.J. Anderson of the Aquatic Weeds Control Laboratory, Davis, CA, was able to cut hydrilla reproduction by 50 percent, by using night lighting. The Potomac is one of many U.S. waterways that hydrilla—if uncontrolled—could easily clog.

"We hit hydrilla when it was vulnerable," Anderson said in describing his experiments of August-September 1985. "Our strategy was to shine overhead lights on these plants at a time when they need uninterrupted stretches of darkness to form reproductive parts." He estimates that a 75- to 95-percent drop in reproduction might be possible; he has already been able to reduce formation of reproductive buds by 95 percent in laboratory tests.

At a Potomac River marina in Alexandria, VA, plant physiologist Lars Anderson places strands of reproduction-foiling lights in heavy mats of hydrilla. Assisting Anderson are research associate Madeline Ames and aquatic ecologist Steven Spencer. (0885X866-29)

Marinas and other sites where electricity is readily available would be the most practical sites for the night-lighting approach.

"If we can use night lighting for several years in a row, to slow formation of reproductive buds, we may be able to get the weed under control," Anderson says. The best use of night lighting may be to combine it with other, more conventional techniques, such as mowing with mechanical harvesters, using divers to maneuver underwater vacuums to suction hydrilla from river bottoms, or applying herbicides.

Hydrilla reproduces from small, bulblike reproductive parts known as tubers and turions. The lengthening of nights during summer and fall triggers formation of the tubers in the soil and turions on the tips of shoots. In the fall, when the plant dies, the turions either fall off or break off the shoots; they drift with the current and eventually sink to the bottom. The tubers remain in the soil. In the spring, both the tubers and the turions sprout and form new plants.

"It's true that hydrilla can spread in other ways, such as from pieces clipped off by an outboard motor," Anderson says. "But the newly established plants will eventually need to form tubers or turions in order to survive the winter and reproduce. That's where night lighting comes in."

Hydrilla has been reported in more than a dozen states, from Florida to California. If uncontrolled, dense mats of the hardy plant can entangle swimmers or boaters, snag fishing lines, and interfere with irrigation and flood control. The weed can grow from 2 to 4 inches a day, forming strands 10 to 15 feet long.

The idea of using lighting to confuse plants and disrupt normal reproduction isn't new. It's a trick that's widely used to produce poinsettias, chrysanthemums, and other flowers at times of the year that these plants wouldn't normally be in bloom. The technique is based on what is known as photoperiodism, or the effects of day length on a plant's development.—**Marcia Wood,** ARS, Albany, CA.

Contact Lars W.J. Anderson at the Aquatic Weeds Control Laboratory, 222 Robbins Hall, University of California, Davis, CA 95616. ■

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PATENTS

Spinning Filament Seed Thresher

See "New Flower Seed Thresher Cuts Hand Labor," p. 14, for information on *Patent Application Serial No. 779,958, "Filament Seed Thresher."* ■

Softer Permanent-Press, Flame-Retardant Clothes

This new treatment gives cotton-polyester and other blend fabrics a finish that is both permanent-press and flame-retardant.

The old method tends to make fabrics stiff because of chemicals added to the finish to trap the treatment compounds on the fabric's surface. The new method relies instead on reactive compounds which chemically bind the treatment compounds deep inside the fabric.

For technical information, contact Robert J. Harper, Jr., USDA-ARS Southern Regional Research Center, P.O. Box 19687, New Orleans, LA 70179. *Patent Application Serial No. 749,905, "Process to Impart Smooth-Dry and Flame-Retardant Properties to Synthetic-Cellulosic Blended Fabrics."* ■

Cancer Inhibitor Found in Plant

Scientists have found rare anticancer compounds in a plant not a member of the only two plant families previously known to have the compounds. What's more, the compounds found this time have a slightly different chemical structure than other reported ansa macrolide compounds.

Laboratory tests have shown the unique compounds found in *Trewia nudiflora,* a tree native to tropical areas of India, are effective against cultivated cells of human epidermoid carcinoma of the mouth and two types of cancer in mice.

For technical information, contact Richard G. Powell, USDA-ARS Northern Regional Research Center, 1815 N. University Street, Peoria, IL 61604. *Patent No. 4,313,946, "Chemotherapeutically Active Maytansinoids from 'Trewia Nudiflora'."* ■

Fungicide Pellets with Live Fungi Inside

Now there's a way to put living fungi in a gel pellet to kill harmful soilborne fungi.

The fungi, together with wheat bran for food, are added to a sodium alginate solution. All the ingredients are blended and then added to a calcium salt solution, drop by drop. Each drop forms a gel bead which dries into a pellet.

The pellets tested produced living colonies of fungi when applied to farmland. The fungi effectively controlled *Rhizoctonia solani,* preventing damping-off disease of cotton and sugar beet seedlings.

For technical information, contact Jack Lewis, USDA-ARS Soilborne Diseases Laboratory, Bldg. 011A, BARC-West, Beltsville, MD 20705. *Patent Serial No. 749,906, "Preparation of Pellets Containing Fungi and Nutrient for Control of Soilborne Plant Pathogens."* ■

How to Obtain a License for USDA Patents

A listing of all U.S. Department of Agriculture patents is available on request. If you are interested in applying for a license on a patent or receiving the catalog, write to the Coordinator, National Patent Program, USDA-ARS, Rm. 401, Bldg. 005, Beltsville, MD 20705.

Copies of existing patents may be purchased from the Commissioner of Patents and Trademarks, U.S. Patent and Trademark Office, Washington, DC 20231. Copies of pending patents may be purchased from National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161. ■